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Report on

GS8a

Goulburn-Murray

Shepparton Irrigation Region

Stage 5

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GS8a – Goulburn-Murray: Shepparton Irrigation Region

Stage 5 – Assessment through multiple lines of evidence

The Goulburn Murray: Shepparton Irrigation Region SDL resource unit (GS8a) is located in northern Victoria, within the catchment of the River Murray, and the Shepparton Irrigation Region (SIR) Groundwater Management Area (GMA), which encompasses several tributaries, including downstream areas of the Campaspe, Goulburn and Broken Rivers (Figure 1). The system consists of an unconfined sedimentary aquifer comprised of the Shepparton and Coonambidgal Formations, which overlies GS8c. From a management perspective, GS8a includes all groundwater contained within these units to a depth of 25 m (MDBA, 2020). Groundwater extraction is focussed in areas of usable water quality and viable yield; there are two main zones of dense allocations, one south of the Goulburn River (centred around Kyabram) and one north of Broken Creek (south of Cobram; Figure 1). GS8a spans approximately 6,566 km², and has a Sustainable Diversion Limit (SDL) of 244.10 GL/year, and a long-term average recharge of 498.00 GL/year (Table 1). Between 2013 and 2023, average annual groundwater extraction in GS8c was 58.30 GL/year, representing 24% of the SDL, and 12% of recharge (Figure 2). Groundwater use supports intensive irrigated agriculture (Figure 2) and is encouraged in order to manage groundwater levels, avoiding further mobilisation of salt by preventing rising water tables (DELWP, 2019a). The primary objective of groundwater entitlements in GS8a is not to meet consumptive demand, but to mitigate the adverse impacts of shallow saline groundwater, particularly waterlogging and land Salinisation. Long-term climate observations show a relatively persistent below-average rainfall signal for the 1995–2010 period, followed by two cycles of above- and below-average rainfall between 2010 and 2020, and a sustained above-average rainfall period post-2020 (Figure 3).

The depth of the median (long-term) water table is shallow (within 10 m of the surface) for almost the entire GS8a area, and very shallow (within 5 m of the surface) in the main areas of entitlement (Figure 4a). Management of waterlogged land due to the elevated water table has since lowered average levels, as seen by the difference between the long-term (1974-2024) and short-term (2012-2024) median groundwater levels in the cross-section (Figure 5). Groundwater flows from south to north and from southeast to northwest (Figure 5), but hydraulic gradients are weak in this area, and there is less than 40 m head difference across GS8a (Figure 4b). Long-term and short-term median groundwater levels show spatial agreement and are contained within a well-defined fluctuation zone that ranges from several meters up to 5 m (Figure 5). The 95th percentile of water levels defines the top of this fluctuation zone and is close to the maximum level of raised water tables since 1974. Water levels were nearest the surface beneath the central zone of pumping south of Cobram, and the lower elevation of the short-term median groundwater levels in this area demonstrates successful mitigation. Groundwater salinity in the GS8a varies significantly, with low-salinity water in localised zones surrounding by increasing salinity in pockets between the main entitlement areas (Figure 6). Water quality often sits in RRAM class 3: 4,478 µS/cm to 20,896 µS/cm (equivalent to 3,000 mg/L to 14,000 mg/L) (Figure 6). Salinity patterns highlight that GS8a is dependent on high seasonal rainfall and strong groundwater management for good groundwater quality (DELWP, 2019a). Monitoring of water level trends was detailed and widespread in the long-term period due to investigation of salinity issues that developed from land use practices prior to the 1970s. Observations show a mixture of stable and declining trends, and many sites responding to active mitigation measures to reduce groundwater levels (Figure 7; Figure 9). Observations have similar trends in the short-term, although fewer bores were monitored (Figure 10). The records often show bores with no statistically significant trend adjacent to declining trends (e.g. Figure 9), which is due to the shoestring sand lithology of the aquifer, and slow release of water from silty bands. The understanding of temporal salinity trends is relatively strong in GS8c due to historical water quality issues (Figure 8).

MDBA (2020) previously reported recharge for GS8c as 498.00 GL/year, which incorporates diffuse, irrigation, floodplain, and in-stream recharge derived from a calibrated groundwater model. In contrast, a recent estimate of the MD-SY2 project using WAVES modelling of diffuse recharge only was 54.04 GL/year (Crosbie et al., 2025). Table 1 shows a storage-to-recharge ratio (S/R) of 153 using the groundwater model estimate of recharge and the WERP estimate of storage (Rojas et al., 2022), suggesting moderate buffering capacity and moderate vulnerability to short-term climate variability (S/R sits within the “medium responsiveness” bracket¹ defined in Rojas et al., 2022). With an SDL-to-recharge ratio of 49% and extraction-to-SDL of 24%, current use seems moderate in relation to the available recharge (assuming 498.00 GL/year). These characteristics indicate that a reasonable buffer exists to accommodate seasonal and spatial variations in use and recharge.

The productive base shows signs of significant drawdown, with long-term water level declines affecting all areas of the resource unit (Table 1; Figure 9). However, as discussed above, these declines represent deliberate lowering of the water table after unwanted historic increases; therefore, declining levels are not representative of a deteriorating resource condition in GS8a. Statistically significant ($\alpha=0.05$) declines have occurred since 1974 in approximately 62% of the bores with data (Table 1). In contrast, short-term trends (Figure 10) include far fewer bores but show a greater proportion of with declining trends (79% of bores; Table 1). In addition, the long-term bore records included 10% of bores with an increasing trend, which was reduced to zero in the short term (Table 1; Figure 10). Significant wetlands exist along the River Murray and the Goulburn River inside GS8a, which are mapped as potential GDEs; however, these systems are not sustained by groundwater discharge, as it is typically saline. Instead, low-salinity infiltration from flooding and runoff maintains the water availability and quality for these wetlands. Therefore, management strategies focus on lowering the water table to prevent baseflow, especially when dry conditions prevail. Consistent with this, Crosbie et al. (2023) defined most river reaches in GS8a as mostly losing or some losing, with many showing a significant increase in the proportion of data sites showing losing conditions.

Stage 4 of this BPR technical groundwater review provided a quantitative assessment of resource condition indicators within a 5 km buffer around extraction points (asset area). Long-term groundwater level declines were observed in 55% of the productive base asset area, 45% of the river connectivity asset area, and 55% of the GDE asset area (Table 2). In the short-term, these percentages decreased significantly to 26%, 29%, and 26%, respectively (Table 2). A large reduction is observed in proportion of the area showing increasing or stable water level conditions between the long-term and the short-term (Table 2); however, this is due to an increase in uncertainty, rather than more areas showing decreasing levels. The uncertainty, as indicated by areas with insufficient data to inform temporal trends, increased from less than 2% in the long-term, to more than 60% in the short-term for all ESLT values, including salinity (Figure 11; Table 2). Water quality (salinity) ESLT asset areas are dominated by improving trends in the long-term, and are uncertain in the short-term (Table 2).

The Victorian state-based risk assessment (DELWP) (2019b) assigns varying risk ratings across ESLT values in GS8a. High and very high risks to productive base include: the risk of climate change reducing availability of groundwater supply or the supply for Aboriginal uses of water; the risk of earth resources development reducing availability of groundwater supply for Aboriginal uses of water. Medium risks to productive base include: the risk of increased take, extreme events, or farm dam changes reducing availability of groundwater supply for Aboriginal uses of water; and the risk of extreme drought resulting in adverse impacts on human water needs. Risks to GDEs are classified as high, centred around the risk of climate change reducing groundwater levels and resulting in adverse impacts on environmental uses. However, high water tables in some areas of this unit contribute to salinisation and waterlogging, posing a significant threat to agricultural productivity and environmental values, particularly of the River Murray. Although river connectivity is not formally assessed outside of the GDE context, it likely carries risks similar to other ESLT values based on observed trends. Water quality risks range from low to very high, with high and very high risks including: the risk of climate change increasing salinity affecting consumptive users and Aboriginal uses of water. Land use change, earth resources development, point source toxicants, and extreme events were medium risk factors for salinity and water quality. Data availability is generally suitable for water levels but more limited for recent water quality.

¹ S/R ratio: High responsiveness: 29 to 111.
Medium responsiveness: 11 to 333.
Low responsiveness: >333.

Future projections from the MD-SY2 project indicate that diffuse recharge to GS8a may slightly increase by 2050 due to more intense rainfall events (Crosbie et al., 2025). In contrast, overbank flood recharge and in-stream recharge for GS8a is expected to decline by 31.6% and 11.1%, respectively, compared to current conditions (Crosbie et al., 2025). As climate projections indicate warmer and drier conditions for GS8a, accompanied by more intense rainfall events, the net effect may reduce recharge in the long term. These changes could particularly affect GS8a as a shallow aquifer with high evapotranspiration losses, exacerbating salinity issues, or increasing reliance on deeper aquifers such as GS8c. Stage 6 of this BPR technical groundwater review found that the future area of drawdown (Area of Influence, Aol²) is projected to expand under climate change scenarios, as the median future Aol (P50) exceeds the present Aol, indicating likely increases in deteriorating areas (Figure 12). The Stage 6 assessment classified the pressure from future climate change on GS8b groundwater resources as moderate based on long-term water level evidence, and low based on short-term evidence.

Overall, short-term groundwater trends (2012–2024) show that a greater proportion of GS8a bores have declining groundwater levels than in the long-term (1974–2024), indicating active management to reduce waterlogging since salinity issues developed prior to the 1970s. Availability of monitoring data has decreased over time, although knowledge of the resource is comprehensive. Most zones of this aquifer, particularly in the densely allocated areas, continue to see moderate declines in water levels, despite a positive rainfall anomaly after 2020 and a substantial reduction in groundwater extraction. With a recharge rate of 498.00 GL/year and SDL of 244.10 GL/year, the SDL remains conservative in absolute terms, and take is only 24% the SDL. Continuing salinity concerns increase the risk to ESLT values in this unit and success in management requires users to be consistent in their groundwater consumption to prevent saline baseflow to surface water features. In addition, the state-based risk assessment highlights very high and high risks to groundwater availability and quality, particularly from climate change and extreme events such as drought. Climate projections forecast reduced episodic (localised) recharge from floodplain and in-stream processes, meaning that the water balance in GS8a could change in the future. Collectively, the analysis suggests that there is high-to-moderate pressure on the productive base of GS8a, with long-term sensitivity to groundwater salinisation pressure, and moderate pressure from future climatic variability.

² Area of influence is defined as the area impacted by drawdown caused by groundwater extraction. For the quantitative assessment of Stage 4, this is equivalent to the percentage asset area showing a deteriorating resource condition, which is a statistically significant declining trend in groundwater level.

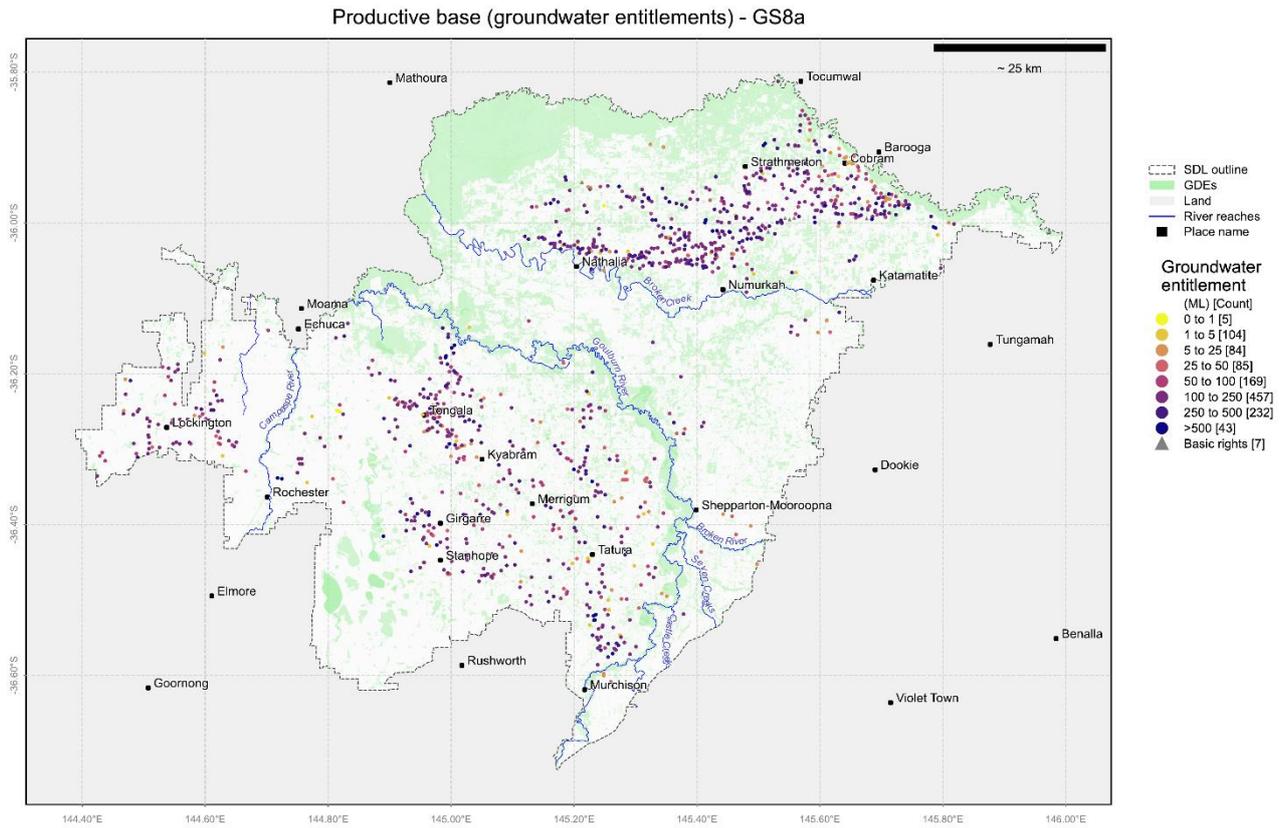


Figure 1 Productive base (groundwater entitlements)

Annual groundwater take and rainfall anomaly for GS8a

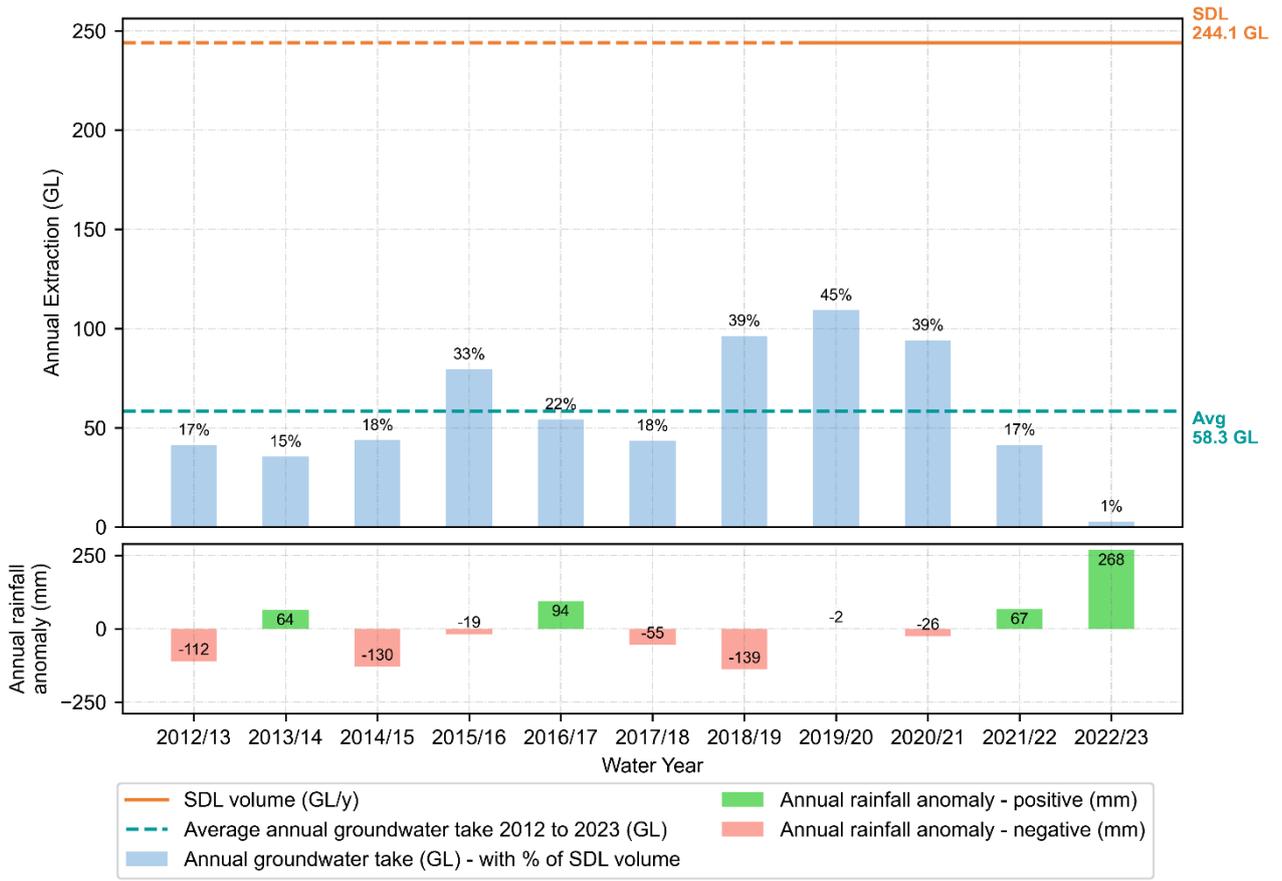


Figure 2 Groundwater take in the SDL since 2012

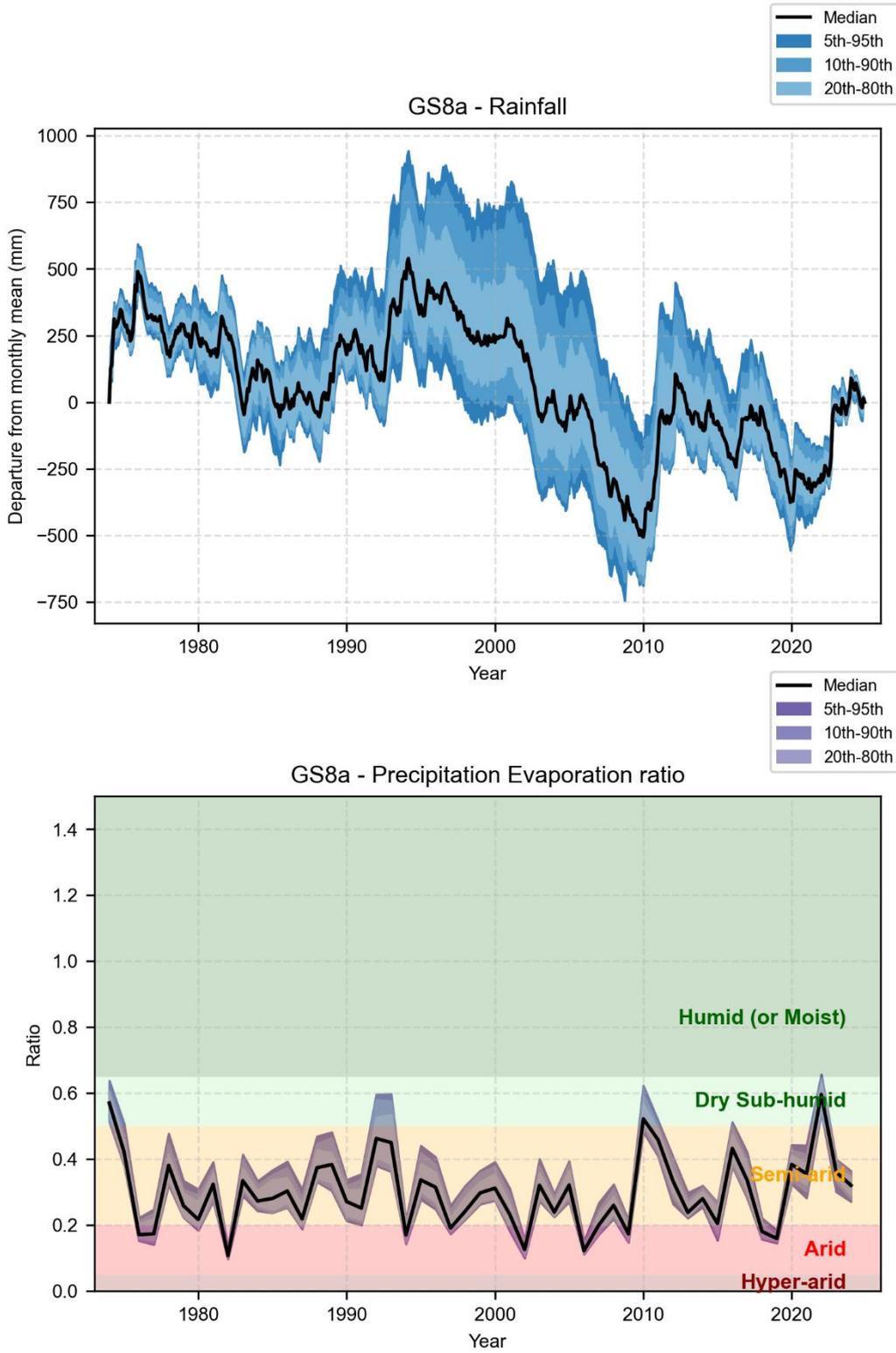
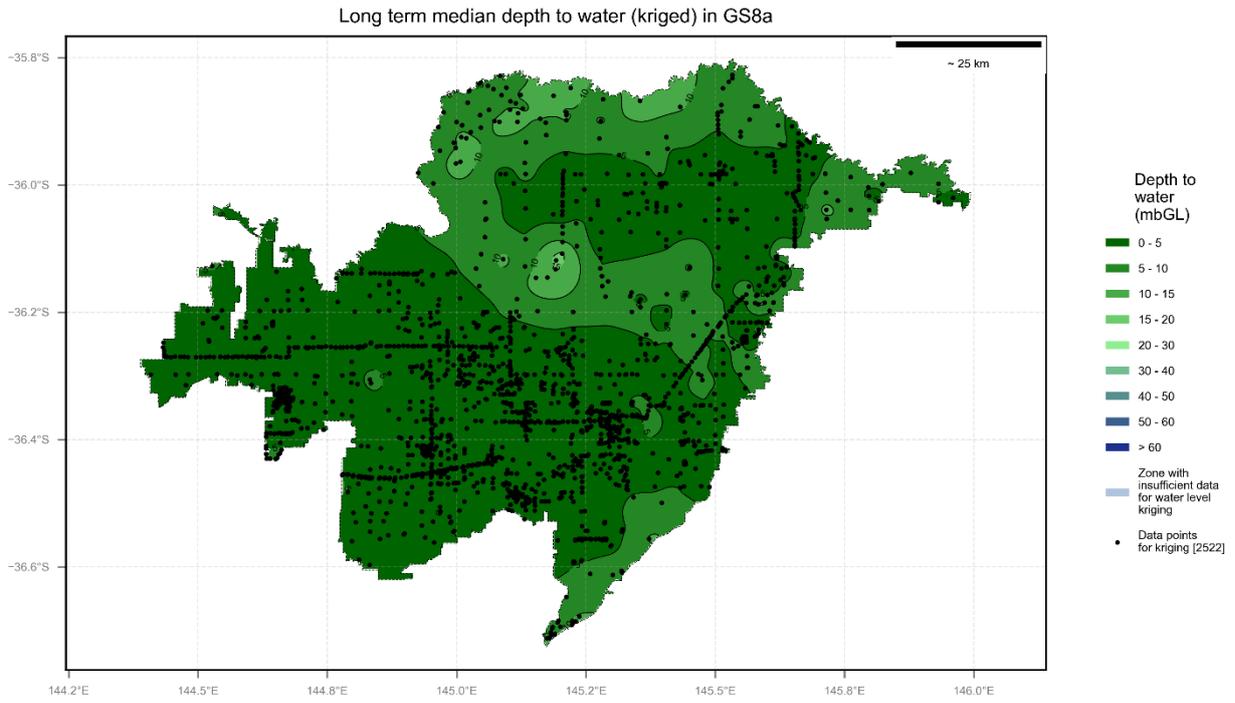
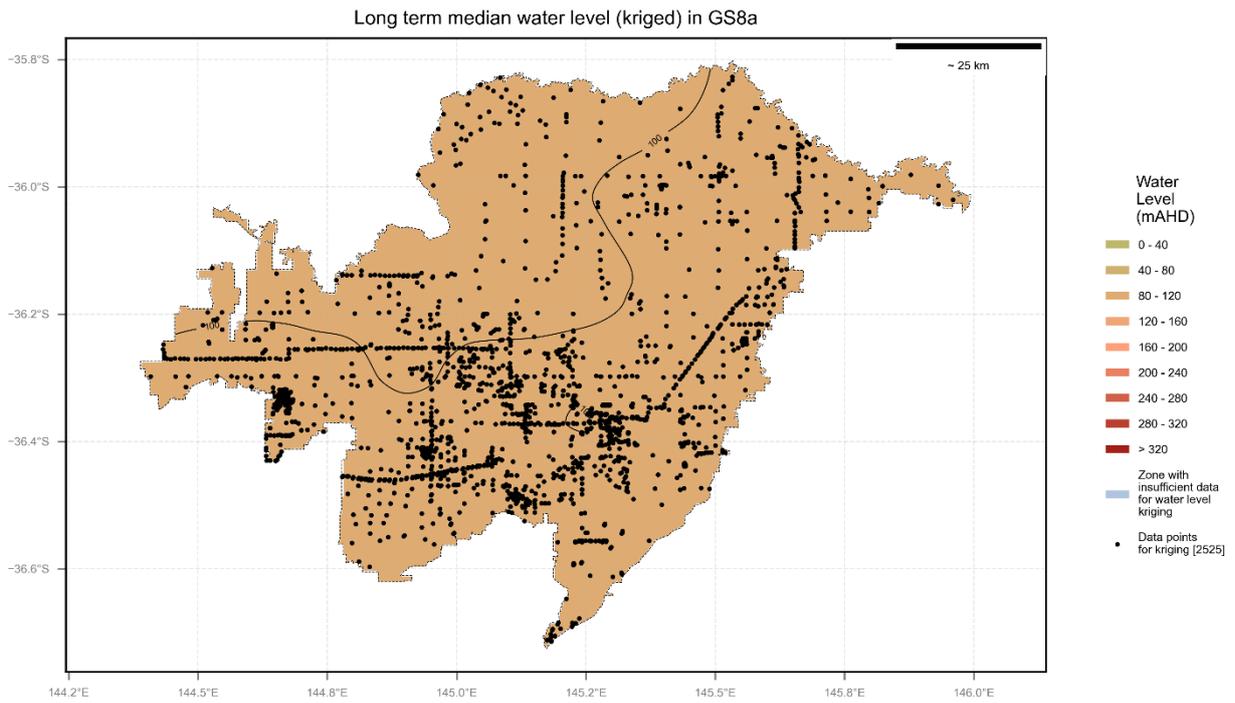


Figure 3 Historical climate trends



Long term - 1974 to 2024; median - 50th percentile water level relative to ground surface

(a)

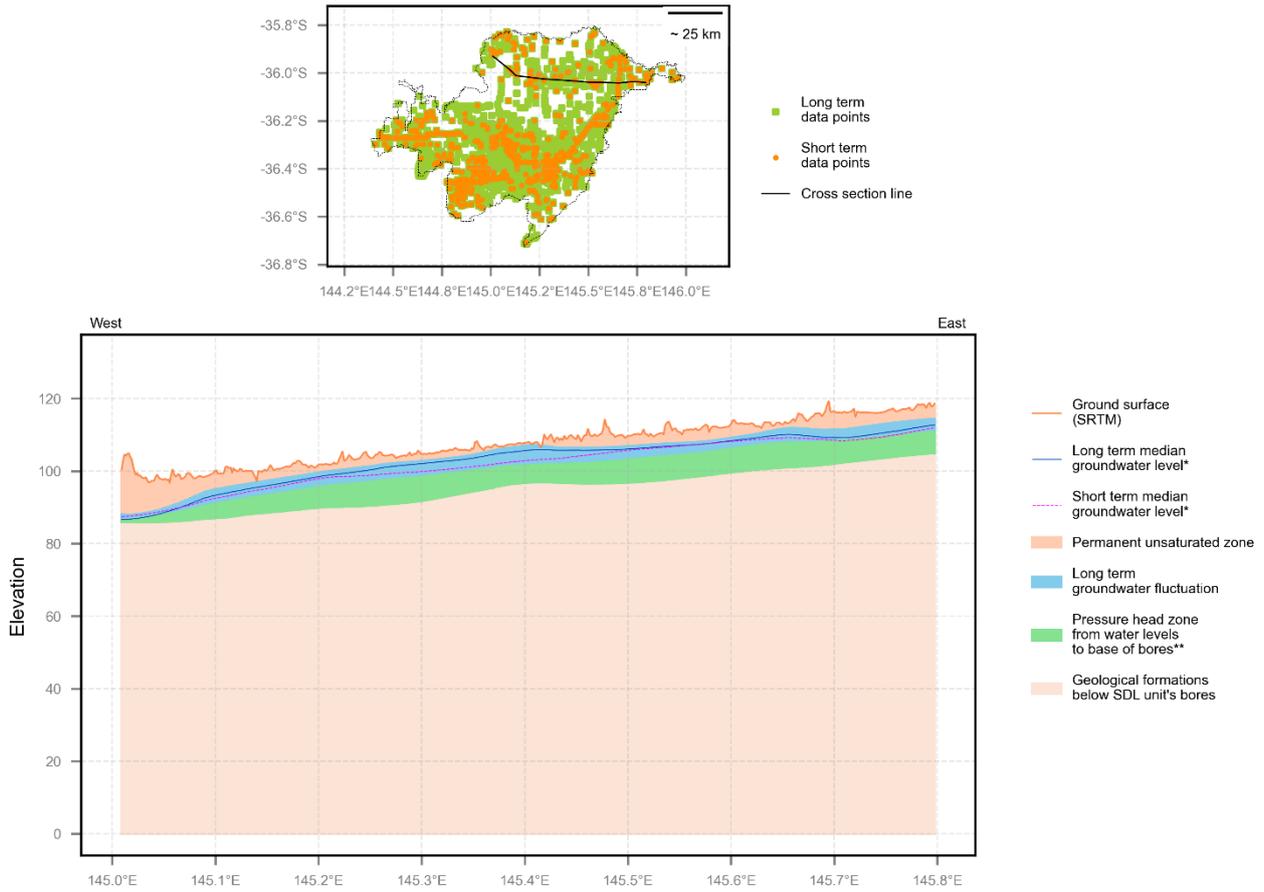


Long term - 1974 to 2024; median - 50th percentile water level relative to Australian Height Datum

(b)

Figure 4 Long-term median (a) depth to water and (b) water level elevation

Water level elevation cross section for GS8a



*Long term - 1974 to 2024; Short term - 2012 to 2024; median - 50th percentile
 **This cross-section is a scaled representation of bore data specific to the SDL resource unit.
 The data are temporally and spatially aggregated, resulting in some smoothing of the representation of water levels and aquifer formations that is different from the detail of reality.
 The blue zone represents the long term fluctuation in groundwater levels, as indicated by the 5th and 95th percentiles of groundwater levels from 1974 to 2024.
 The green pressure head zone may be representative of the total available drawdown (TAD), as it shows the water column in bores of the SDL resource unit (measured as the difference between the long-term 5th percentile groundwater level and the base of the bores of the SDL resource unit).
 This cross-section is for interpretation purposes only and should not be used for planning or compliance purposes.

Figure 5 West to east distribution of water levels in the SDL resource unit

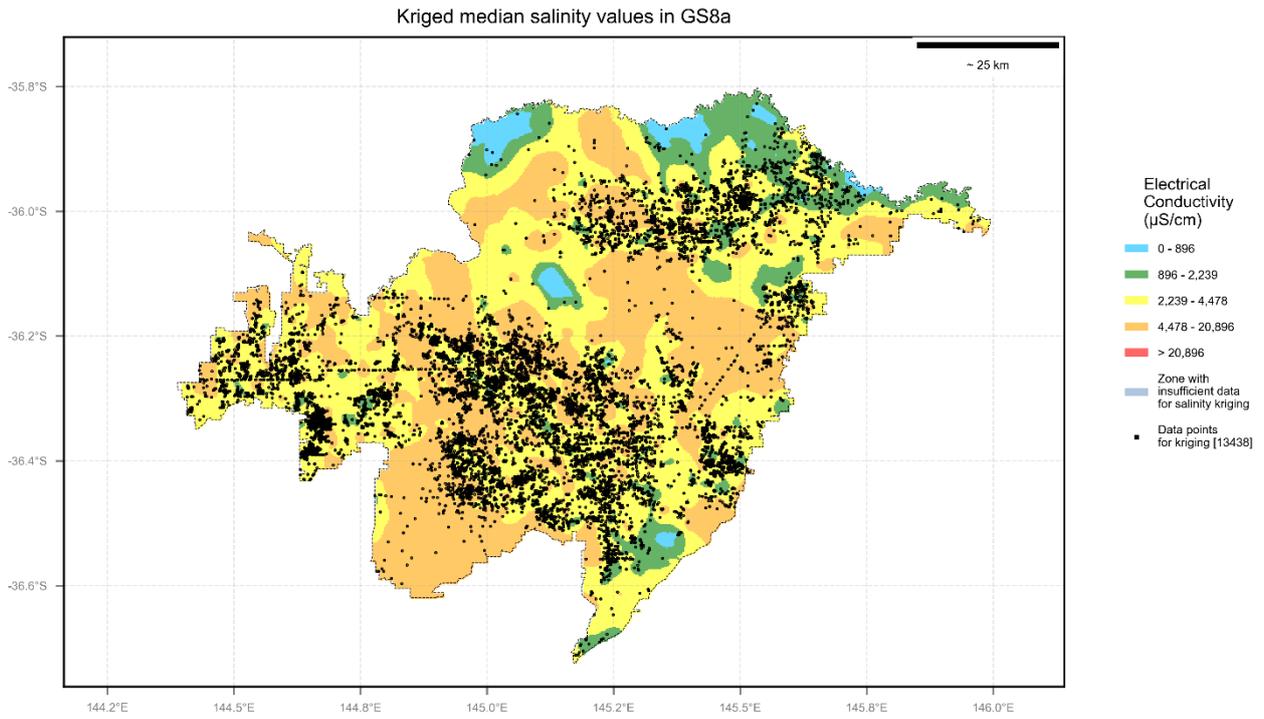


Figure 6 Groundwater salinity distribution

Table 1 Table of groundwater metadata for the SDL resource unit

Parameter	Unit	Long-term (1974 to 2024)	Short-term (2012 to 2024)	SDL resource unit data
SDL volume	GL/y	-	-	244.10
SDL resource unit area	km ²	-	-	6,566
Average annual take (2013 to 2023)	GL/y	-	-	58.30
Number of groundwater entitlement bores	-	-	-	1,187
SDL resource unit storage estimate*	GL	-	-	75,998
Recharge estimate (SY1)	GL/y	-	-	498.00
Recharge estimate (Stage 2)	GL/y	-	-	498.00
Diffuse recharge estimate (SY2 - WAVES)	GL/y	-	-	54.04
Extraction/SDL (E/SDL) (Stage 2 result)	-	-	-	0.24
SDL/Recharge (SDL/R) (Stage 2 result)	-	-	-	0.49
SDL/Recharge (SDL/R) (SY2 or modelled recharge)	-	-	-	0.49
Storage/Stage 2 Recharge (S/R)	-	-	-	153
Storage/SY2 or modelled Recharge (S/R)	-	-	-	153
Number of bores in the SDL unit	-	29,527	29,527	-
Number of bores for water level trend analysis	-	13,078	1,760	-
Number of bores for water level trend with sufficient data	-	2,546	43	-
Number of bores with decreasing water level trend	-	1,589	34	-
Number of bores with increasing water level trend	-	253	0	-
Number of bores with no statistically significant water level trend	-	704	9	-
Mean water level trend magnitude	m/y	-0.05	-0.1	-
Minimum water level trend magnitude	m/y	-0.65	-0.33	-
5%ile water level trend magnitude	m/y	-0.21	-0.23	-
10%ile water level trend magnitude	m/y	-0.16	-0.2	-
50%ile water level trend magnitude	m/y	-0.05	-0.08	-
90%ile water level trend magnitude	m/y	0.04	0	-
95%ile water level trend magnitude	m/y	0.12	0.01	-
Maximum water level trend magnitude	m/y	1.05	0.01	-
Number of bores for salinity trend analysis	-	14,005	478	-
Number of bores for salinity trend with sufficient data	-	2,255	2	-
Number of bores with decreasing salinity trend	-	363	0	-
Number of bores with increasing salinity trend	-	540	0	-
Number of bores with no statistically significant salinity trend	-	1,352	2	-
Mean salinity trend magnitude	µS/cm/y	36	-547	-
Minimum salinity trend magnitude	µS/cm/y	-2,498	-1,064	-
5%ile salinity trend magnitude	µS/cm/y	-318	-1,012	-
10%ile salinity trend magnitude	µS/cm/y	-179	-960	-
50%ile salinity trend magnitude	µS/cm/y	9	-547	-
90%ile salinity trend magnitude	µS/cm/y	294	-134	-
95%ile salinity trend magnitude	µS/cm/y	545	-82	-
Maximum salinity trend magnitude	µS/cm/y	2,119	-31	-

Note: *Groundwater resource storage estimate source: WERP (RQ8b).

Table 2 Table of results from spatial analysis of RCI trends in ESLT asset areas

ESLT Value	Asset area (m2)	Long-term				Short term			
		Proportion of asset area with improving/stable RCI trends	Proportion of asset area with deteriorating RCI trends	Proportion of asset area with uncertain RCI trends	Trend grouping	Proportion of asset area with improving/stable RCI trends	Proportion of asset area with deteriorating RCI trends	Proportion of asset area with uncertain RCI trends	Trend grouping
Productive base	5,526,112,383	42%	55%	2%	Deteriorating trends	7%	26%	67%	Insufficient data
GDEs	5,526,112,383	42%	55%	2%	Deteriorating trends	7%	26%	67%	Insufficient data
River connectivity	2,818,095,219	49%	45%	6%	Variable trends	7%	29%	64%	Insufficient data
Water quality	5,526,112,383	79%	16%	5%	Improving / stable trends	3%	0%	97%	Insufficient data

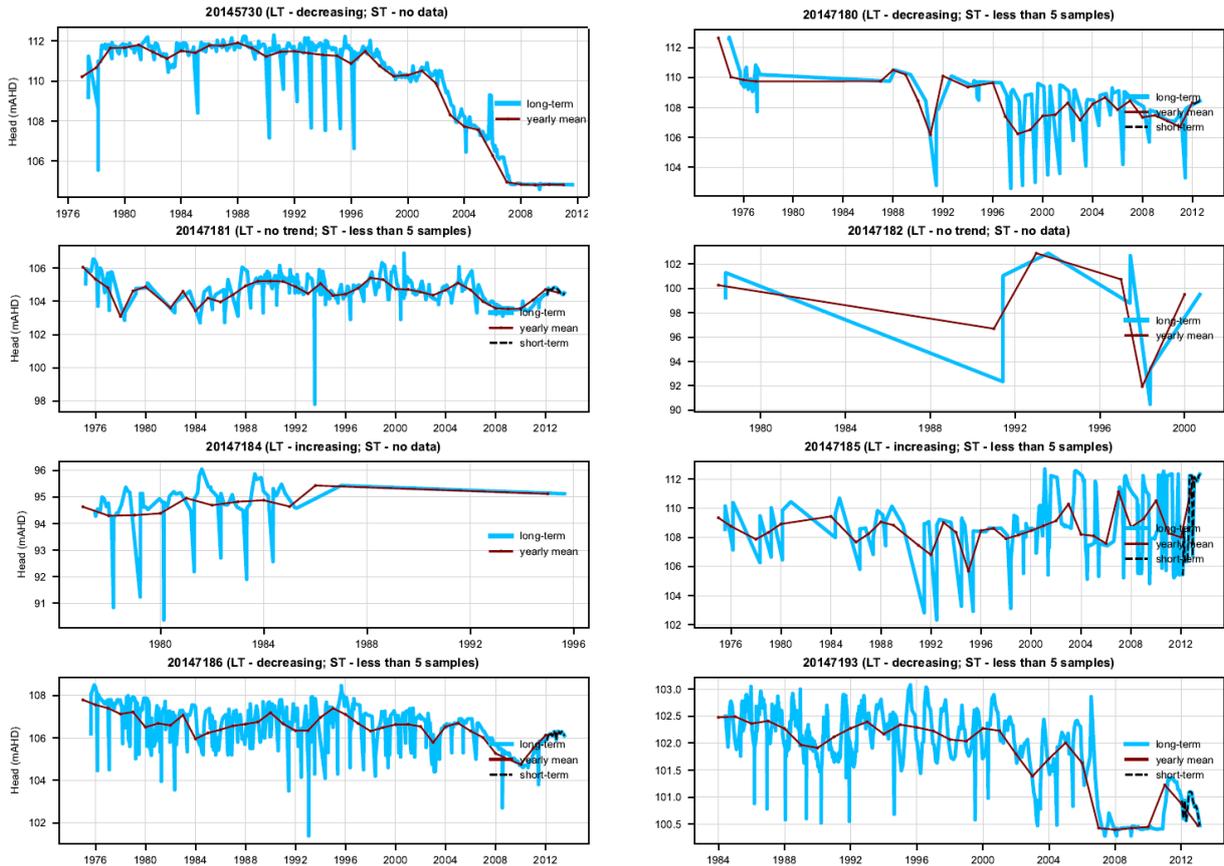


Figure 7 Representative groundwater hydrographs for the SDL resource unit



Figure 8 Representative groundwater salinity time series for the SDL resource unit

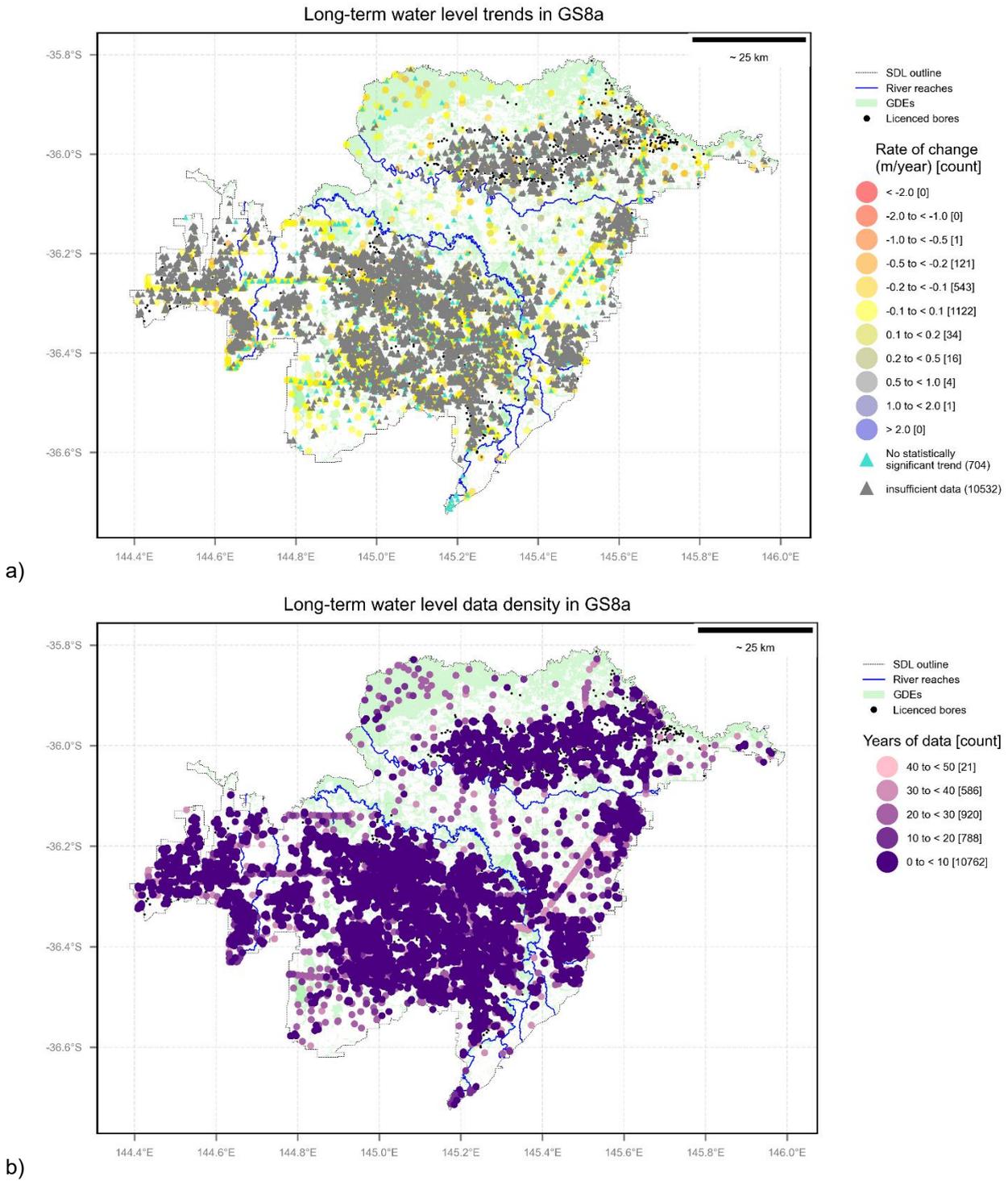


Figure 9 Long-term (1974 to 2024) groundwater level trends (a) and data availability (b)

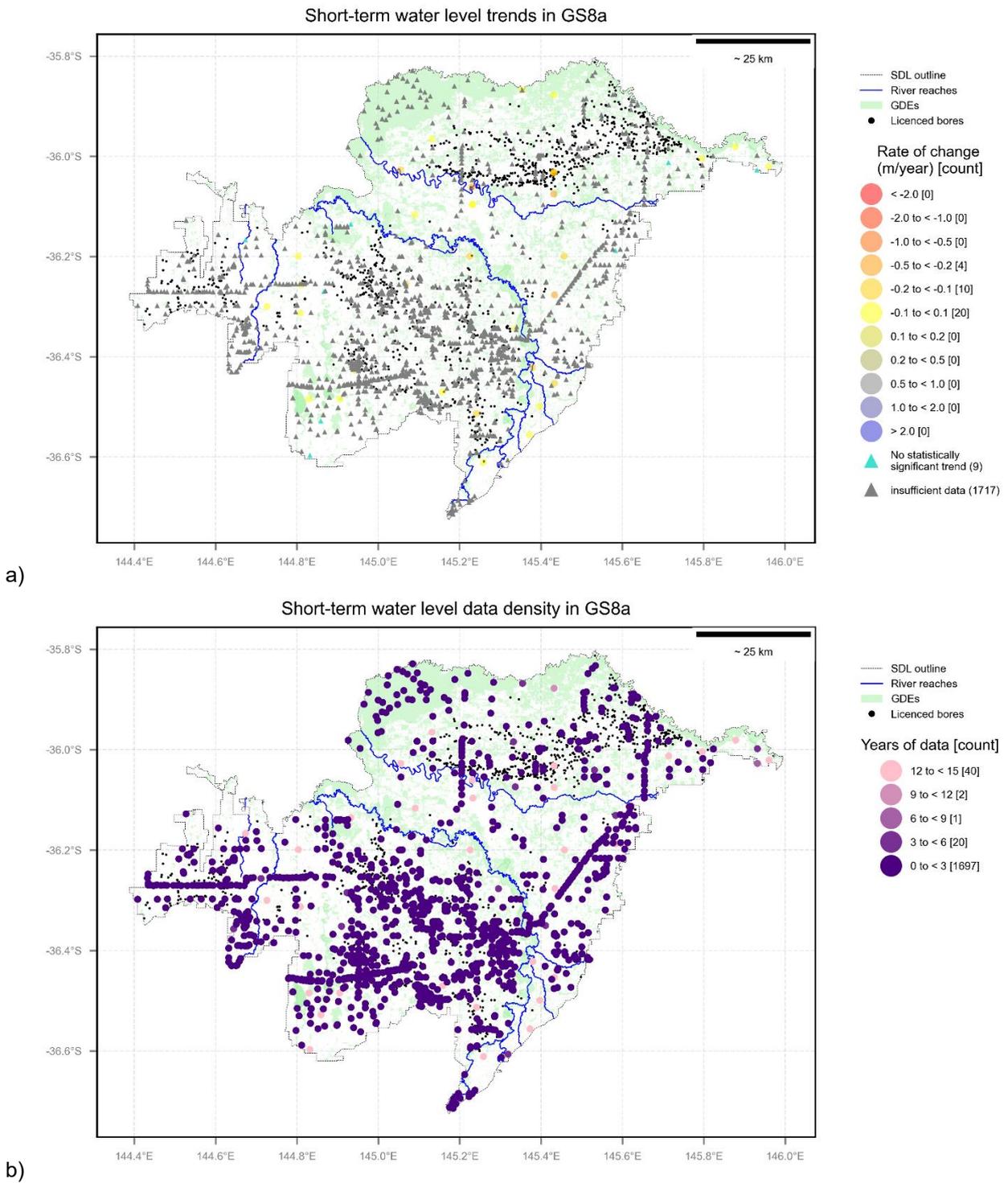


Figure 10 Short-term (2012 to 2024) groundwater level trends (a) and data availability (b)

Ternary plot for GS8a

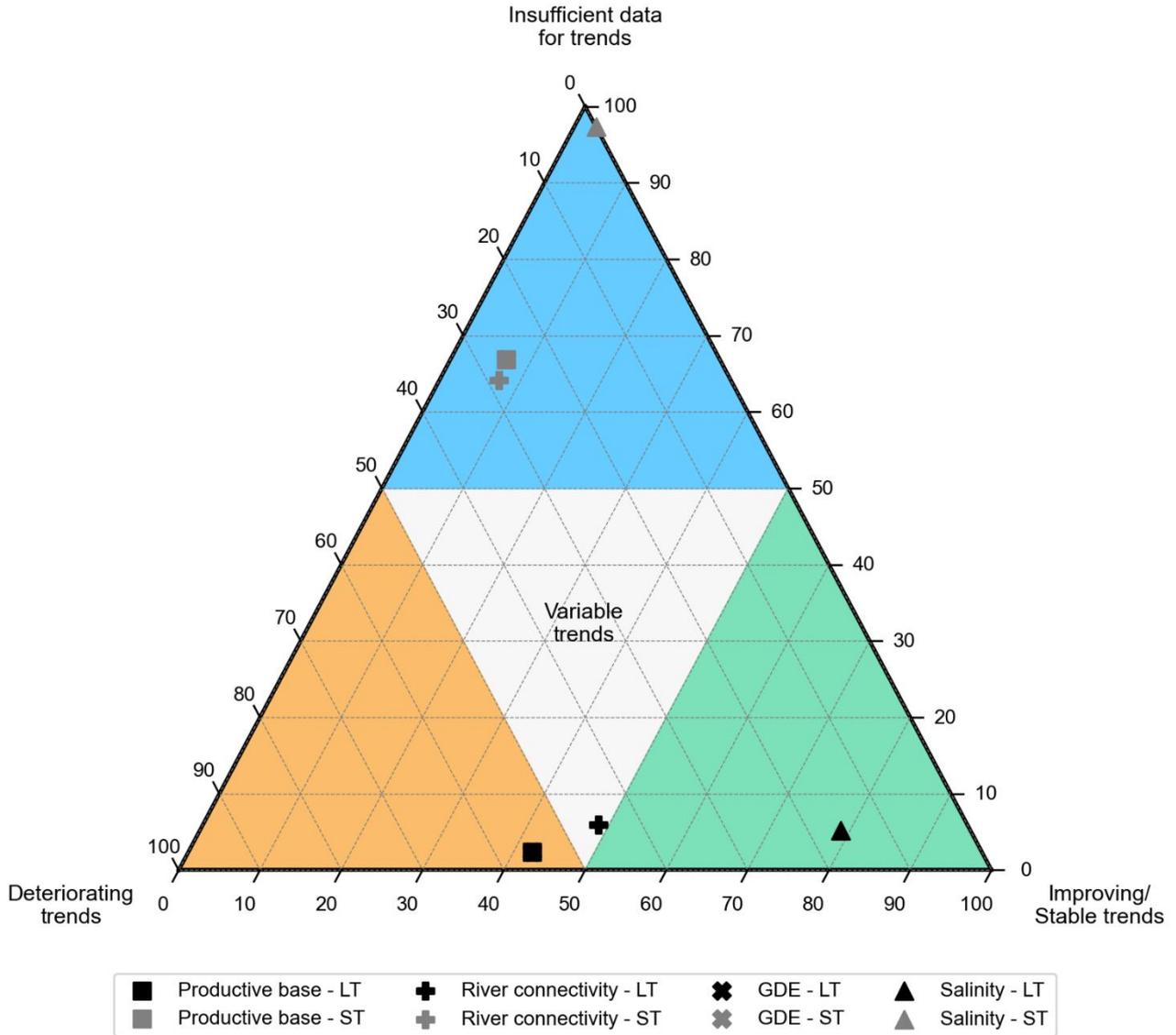


Figure 11 Stage 4 assessment outcome: trends in resource condition indicators for ESLT values

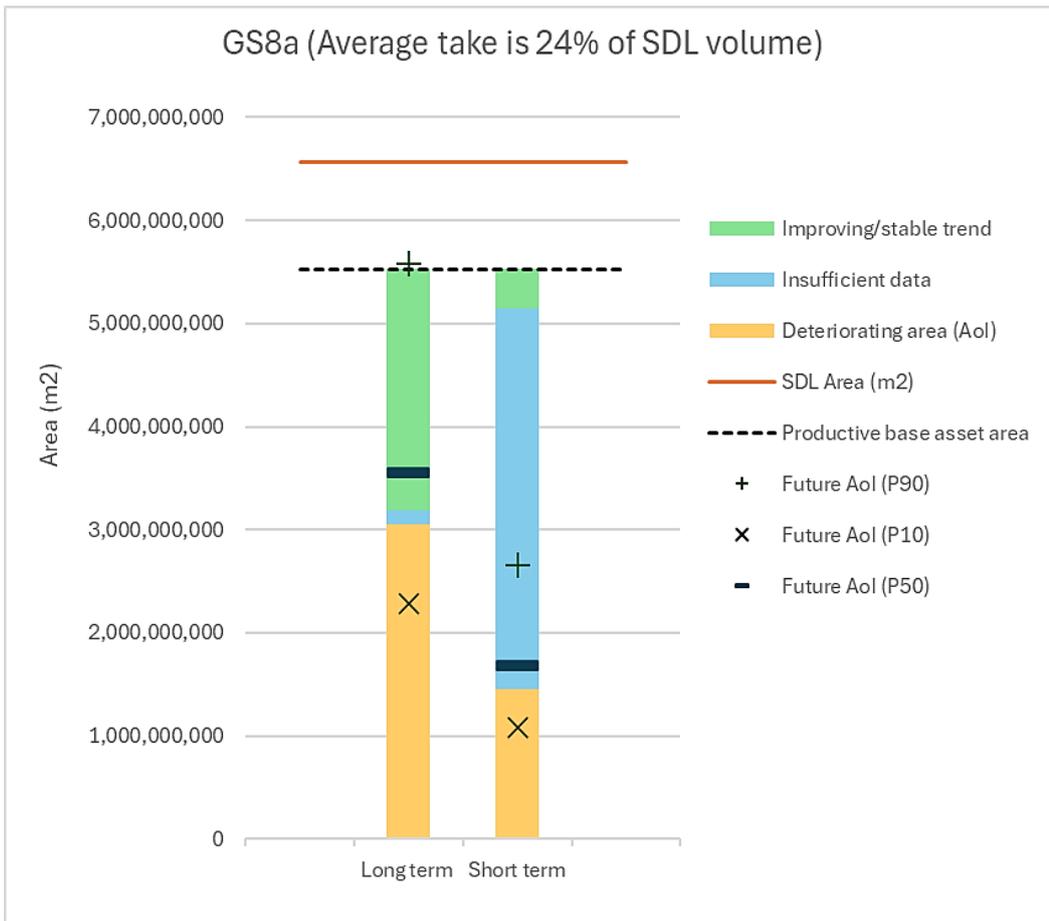


Figure 12 Estimates for change in area of influence (Aol) due to climate change

References

- Crosbie R, Wang B, Kim S, Mateo C, and J Vaze (2023) Changes in the surface water – Groundwater interactions of the Murray-Darling basin (Australia) over the past half a century. *Journal of Hydrology*, 622, doi:10.1016/j.jhydrol.2023.129683.
- Crosbie R, Doble R, Fu G, Campos Teixeira P, Pickett T, Devanand A, Ticehurst C, Gibbs M, Gunner W, Gonzalez D, Post D. (2025) "Groundwater recharge modelling of the Murray-Darling Basin under historical and future climate conditions". MDB Sustainable Yields 2, Module 3a. CSIRO Report, 2025.
- MDBA (2020) Groundwater report cards For Sustainable Diversion Limit Resource Units under the Murray–Darling Basin Plan. Canberra, Australia. www.mdba.gov.au/sites/default/files/publications/mdba-groundwater-report-cards-november-2020.pdf.
- Rojas R., Fu G. and González D. (2022) “*Groundwater level trends and aquifer prioritisation in the Murray-Darling Basin*”. Project RQ8b: Groundwater as an adaptation option to current water resources management. Deliverable T.8b.2 - 31 May 2022. <https://www.mdba.gov.au/sites/default/files/publications/groundwater-level-trends-and-aquifer-prioritisation-in-the-murray-darling-basin.pdf>.
- Victorian Department of Environment, Land, Water and Planning (DELWP) (2019a), Victoria’s North and Murray Water Resource Plan Comprehensive Report, Available from: www.mdba.gov.au/sites/default/files/publications/vic-north-and-murray-water-resource-plan-index-table-and-comprehensive-report-26-November-2019.pdf, accessed on 23 January 2025.
- Victorian Department of Environment, Land, Water and Planning (DELWP) (2019b), MDBA, 2019, Appendix B - Approaches to addressing risk. Available from: www.mdba.gov.au/sites/default/files/publications/vic-north-and-murray-water-resource-plan-appendices-26-november-2019.pdf, accessed on 24 January 2025.